HIGH PRECIS1ON PIEZOELECTRIC LINEAR MOTORS FOR OPERATIONS AT CRYOGENIC TEMPERATURES AND VACUUM.

D. Wong*, G. Carman*, M. Stam*, Y. Bar-Cohen**, A. Sen**, P. Henry**, G. Bearman** and J. Moacanin**.

The Jet Propulsion Laboratory evaluated the usc of an electromechanical device for optically positioning a mirror system during the pre-project phase of the Pluto-Fast-Flyby (PFF) mission. The device under consideration was a piezoelectric driven linear motor functionally dependent upon a time varying electric field which induces displacements ranging from submicrons to millimeters with positioning accuracy within nanometers. Using a control package, the mirror system provides image motion compensation and mosaicking capabilities. While this device offers unique advantages, there were concerns pertaining to its operational capabilities for the PFF mission. These issues include irradiation effects and thermal concerns. A literature study indicated that irradiation effects will not significantly impact the linear motors operational characteristics. On the other hand, thermal concerns necessitated an in depth study.

To address the thermal issue, wc constructed an exact electro-elastic-thermal analytical solution, a finite clement model and conducted experimental tests to evaluate the operation of the linear motor at cryogenic temperatures. 'l'his study indicated that severe problems arise when operating this device at low temperatures related to thermal mismatches in the materials causing the motor to "lock up" and degradation of the strain coefficients causing a loss in the motor's efficiency. To address these issues, wc conducted a parametric study to investigate the impact of geometrical changes and material substitutions on the thermal response of the linear motor. This study indicated that the thermal mismatch problem coul d be overcome with several possible reconfigurations. Wc also evaluated the response ofthc motor's drive element (PZT-5h) at temperatures down to 157 Kelvin. Experimental results indicate that mechanical limitations of the piezoelectric ceramic arc strain dependent and electric field independent. "J'bus, degradation in the piezoelectric strain coefficients at cryogenic temperatures are easil y overcome with appropriate modifications to the applied voltage. These preliminary results suggest that the appropriate state variable for nlodcling/predicting. nonlinear and long term response of solid state motors containing piezoelectric material could be strain. Experimental tests on an augmented linear motor at 157 Kelvin demonstrated both clamping and elongation/contraction capabilities supporting the analytical results. Therefore, both analytical and experimental evidence has led to the conclusion that an augmented linear motor can intelligently engineered to operate at the temperature levels of the PFF mission.

Acknowledgments: This program performed under a contract with the National Aeronautics and Space Administration. The authors would like to thank Burleigh instruments, Inc. Fishers, NY for graciously donating linear motors to this project.

* Mechanical, Aerospace and Nuclear Engineering Department, UCLA, Los Angeles, CA.
** Jet Propulsion Laboratory, Pasadena, CA.